Classification of Meteorological Influences Surrounding Extreme Precipitation Events in the United States using the MERRA-2 Reanalysis

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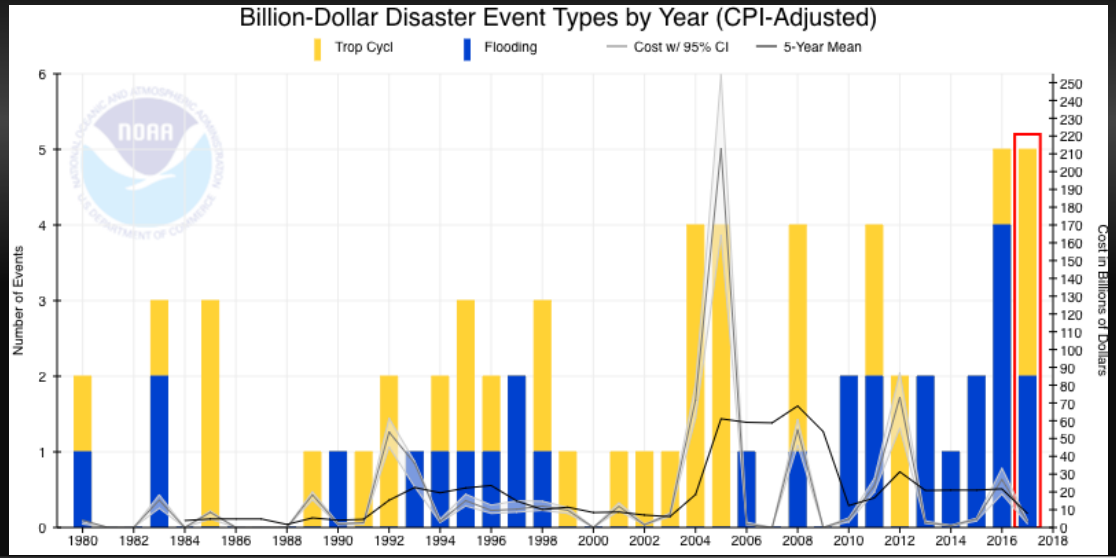
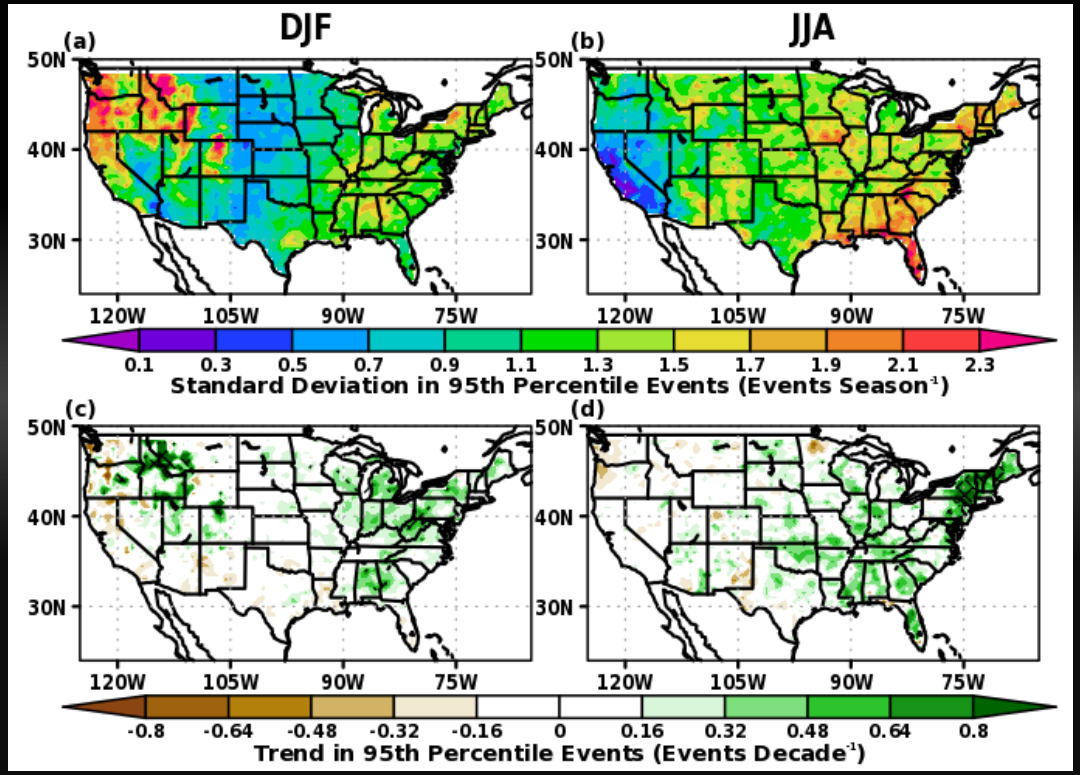
Background

- Extreme precipitation = Day with > 95th percentile of precipitation according to CPC gridded gauge observations
- Can lead to flooding, infrastructure damage, spread of vector borne disease, crop loss, economic damage, fatalities…

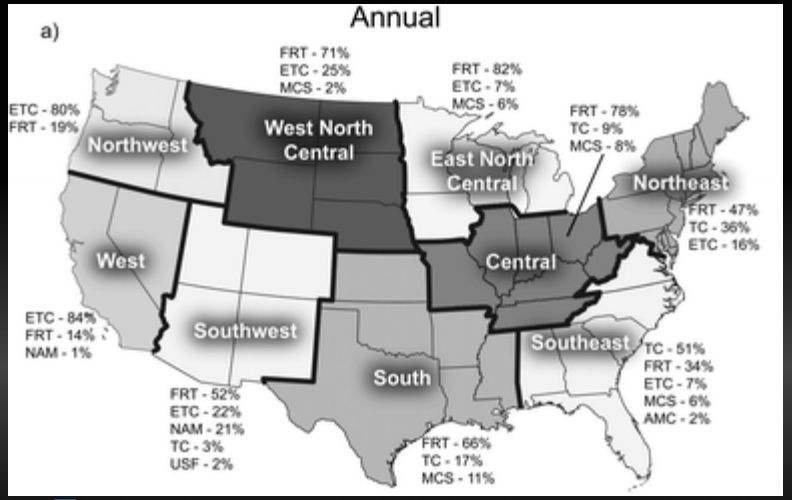


NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2017). (https://www.ncdc.noaa.gov/billions/)

What is behind the interannual variability and trend?



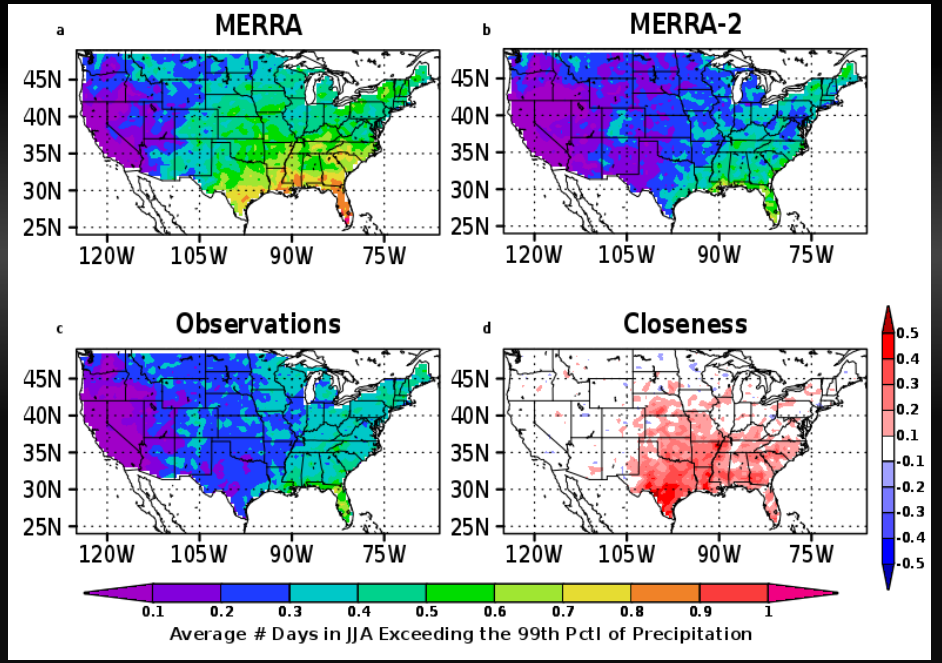
Based on CPC 0.25° Gridded Gauge Observations



Manual analysis of event attribution by Kunkel et al. (2012) – Subjective, tedious, and time consuming

Modern Era Retrospective Analysis for Research and Applications, version 2 (MERRA-2)

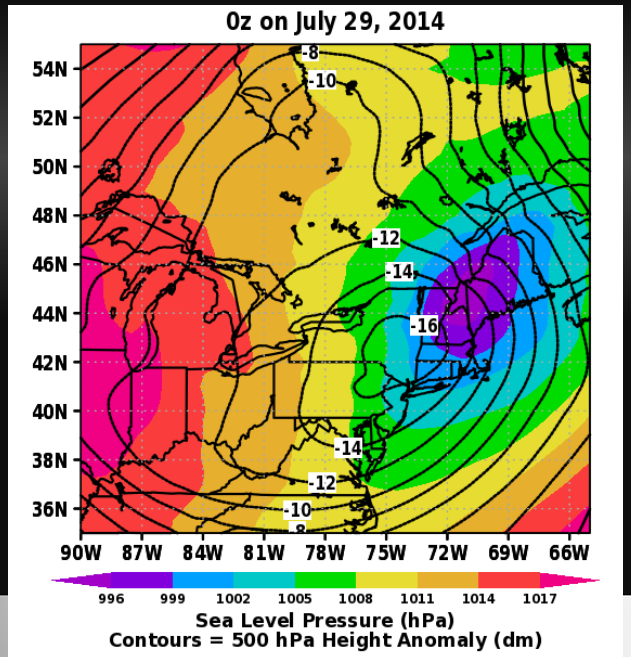
- Spatially and temporally consistent view of the weather with the help of over 62 billion observations and a single version of an atmospheric model
- Hourly information dating back to January 1, 1980 through 2 weeks behind near real time
- Main goal: Connect the analyzed large-scale weather association with historical extreme events to better forecast and prepare for future extremes



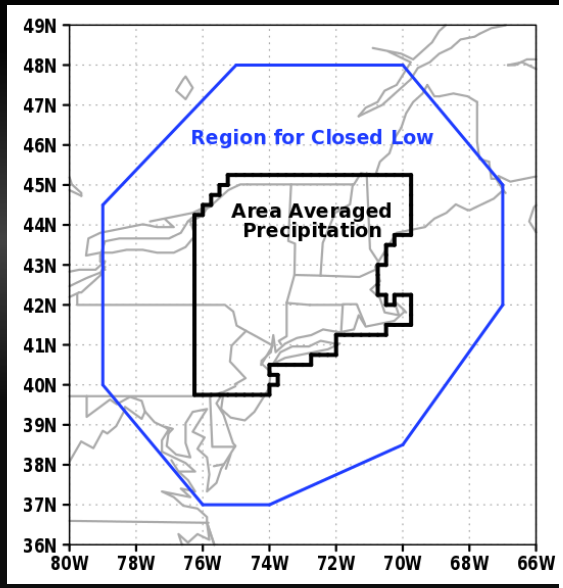
TempestExtremes

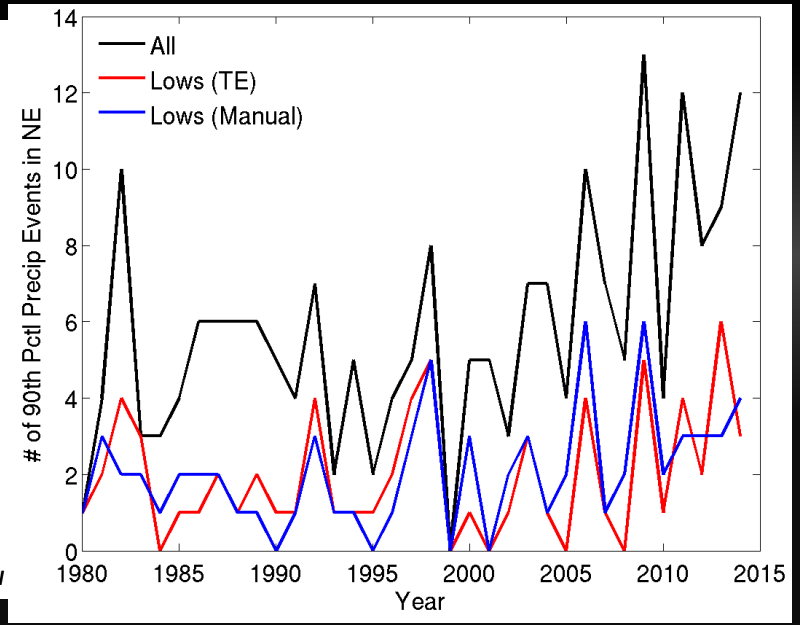
- Feature tracking algorithm developed under PI Paul Ullrich (UC Davis)
- Searches for minima/maxima and merges hits together in time and space
- Used here for closed lows but can also detect tropical cyclones, blocking, and atmospheric rivers

A closed low must have…
•Closed contour in SLP below 1008 hPa
•Negative anomaly in 500 hPa height
•Persisted for a least 24 hours
•Spent a least 24 hours at points with topography below 5,000 m
•Travelled a distance of 5 degrees



Summertime Extreme Precipitation Events Caused by a Closed Low in the Northeast U.S.





-TempestExtremes and a manual analysis give similar, but different results

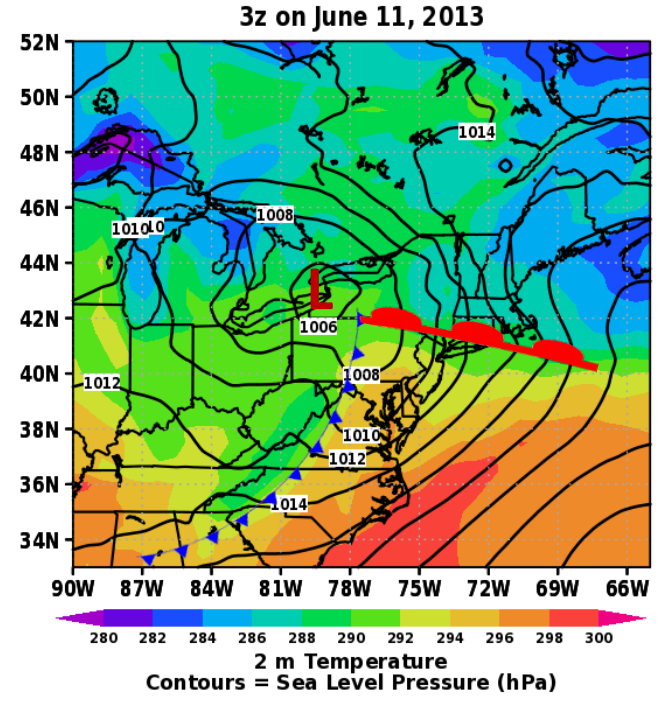
-Both are correct!

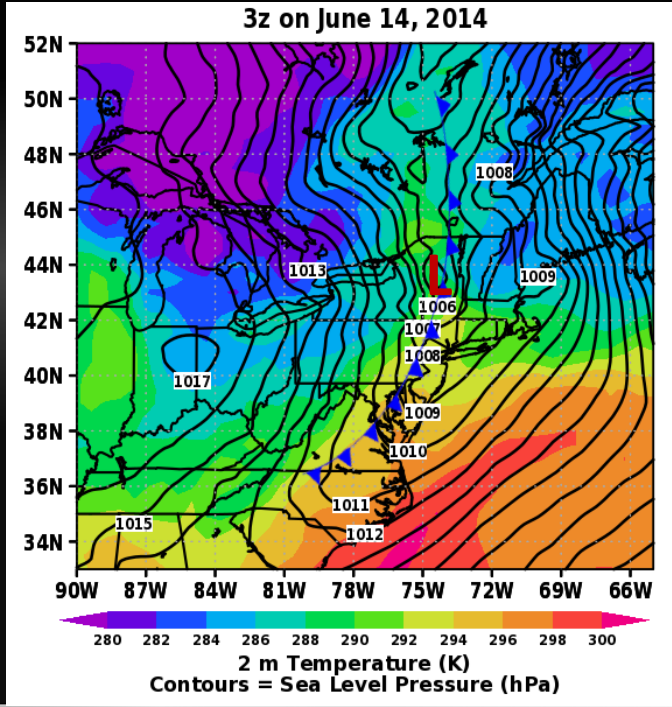
-Manual analysis allowed a closed low to also be defined as a closed contour in 500 hPa height

-Manual analysis also filtered for tropical cyclones and frontal systems

Years with more closed low events in TempestExtremes

- Manual analysis shows event is due to a warm conveyor belt/warm front
- TempestExtremes detects a closed contour in SLP within a cold front





Self Organizing Maps (SOMs)

- Unsupervised neural network approach that organizes a dataset into a grid of characteristic nodes
- Arbitrarily distributes nodes into the data space, iteratively adjusting the nodes to fit the distribution of the data space
- Treats the data as a continuum – event classifications are not always black and white

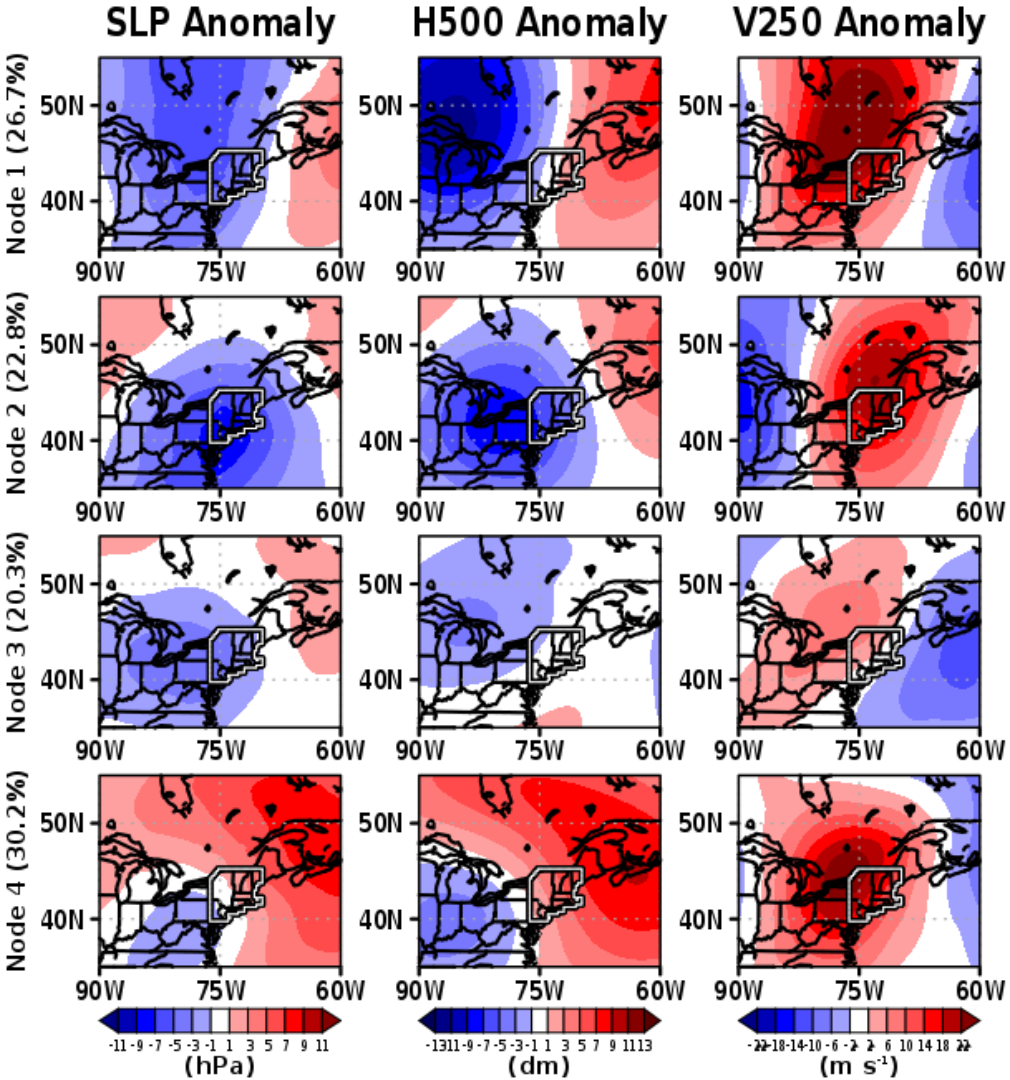
We tested various combinations of:

- Input variables
- Areal coverage
- Iterations
- Learning rates
- Map Dimensions

But were happiest with the results using:

- Anomalies of sea level pressure, 500 hPa height, and250 hPa meridional wind
- An area surrounding the region by 10 to 15°
- 2 stage iteration process (rough, then fine)
- Tens of thousands of iterations
- 1x4 map

SOM Results



Cold Fronts

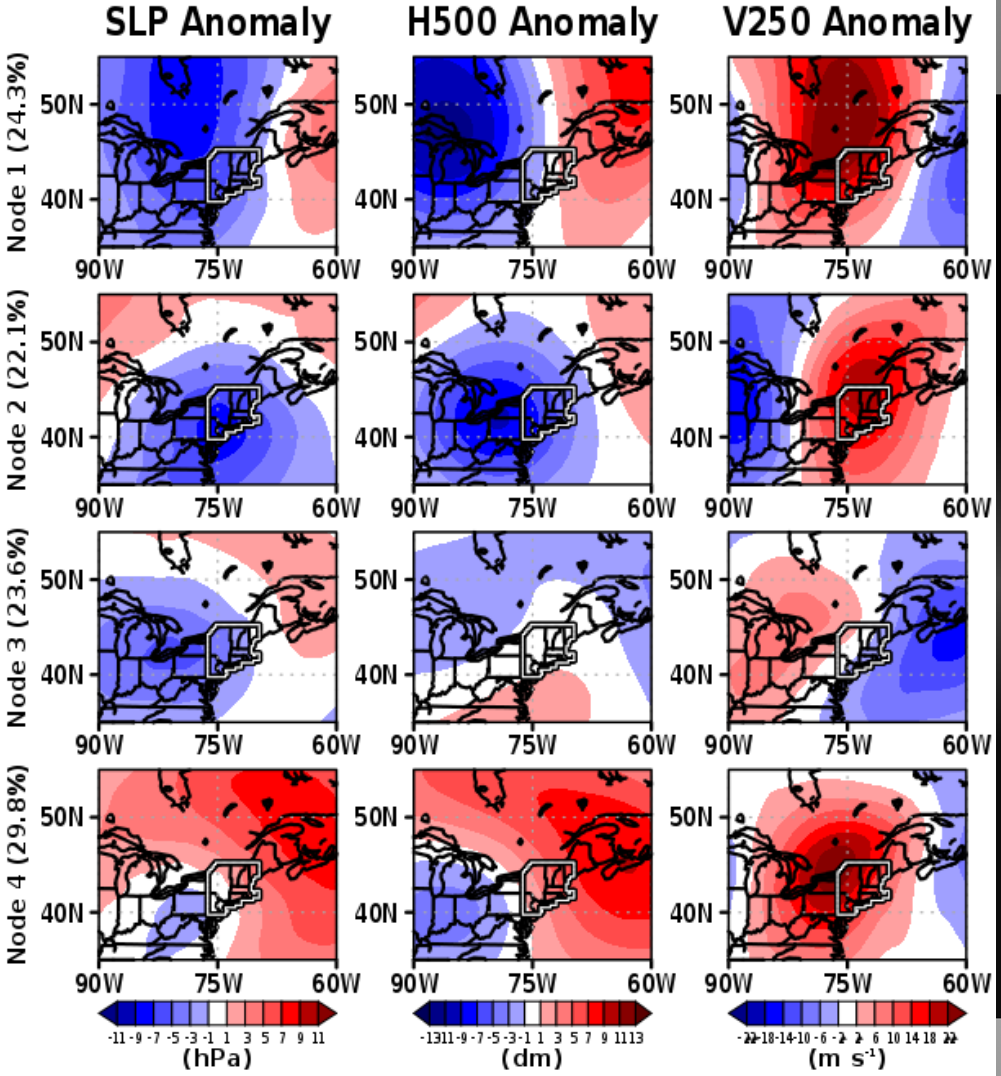
Closed low pressure systems

Weak ETCs, warm fronts

Mix of event types with strong on shore flow

- Tropical cyclones appear in all four nodes
- Variables selected cannot distinguish between tropical and extratropical systems
- Is there a predictive capability if we include the day before an event occurs?

SOM Results (cont.)



Cold Fronts

Closed low pressure systems

Weak ETCs, warm fronts

Mix of event types with strong on shore flow

- What if we remove tropical cyclones?
- Results are very similar -> most events are not tropical
- SLP anomaly weakens in node 1
- Upper level anomalies change in node 3 north of the region

Thank you!

Take Home Messages:

- Two objective classification techniques were used to define attributions to observed extreme precipitation events in the northeastern U.S.
- Results from TempestExtremes were slightly different than a manual analysis, however encouraging
- SOMs had some skill with separating events by dynamical features

Moving Forward:

- Apply both techniques to other regions within the US
- Expand work with TempestExtremes to include blocking and atmospheric rivers
- Investigate predictability of events using SOMs